The Society of Bibliophiles at Brandeis University

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President Marver H. Bernstein and Dr. Bern Dibner holding a copy of Galileo's *Le operazioni dei compasso geometrice e militare,* the young scientist's first work published in Padua in 1606 in an edition of 60 copies. The Vito Volterra Collection which Dr. Dibner has presented to Brandeis University includes in its more than 24,000 items all the first editions of Galileo and nearly all the later editions of the individual treatises as well as those of the collected works.

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THE SOCIETY OF BIBLIOPHILES AT BRANDEIS UNIVERSITY

Arthur E. Vershbow, *President* David S. Berkowitz, *Editor*

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VITO VOLTERRA, 1860–1940: AN OVERVIEW

When Vito Volterra died on October 11, 1940, he was, in the words of one of his contemporaries, ". . . the best known of the many fine mathematicians whom Italy has produced in our time." His life was long, and full of honor and achievement.

He was born in 1860; his life and career thus included the days of Cavour, Mazzini and Garibaldi on one end, and the days of Mussolini and the blackshirts on the other. He was born in a time of political ferment. The expedition of Garibaldi and the Thousand to Sicily and Naples took place in the year of Volterra's birth; the unification of Italy and the liberation of its parts was the encompassing political theme during his early years. Later, when he had the opportunity to speak and to act for freedom, he did not hesitate to do so, even at a major cost to himself.

Vito Volterra was born in Ancona, a small port town on the Adriatic, to Abramo Volterra and his wife Angelica Almagià. His ancestors had lived in Italy for centuries; at some point, probably in the fifteenth century, some ancestor had taken up residence in the town of Volterra, and had, in the fashion of the Jews of his time, adopted the name of the town.

When Vito was two years old, his father, a cloth merchant, died, leaving the family in serious financial condition. With the help of his mother's brother, Vito was able to obtain his education. Throughout most of his youth, he lived in Florence where he first received training in mathematics and physics.

The family's difficult financial situation caused great pressure to be exerted on Vito to enter the world of business; but his extraordinary mathematical talent emerged at a very early age, and was so evident that the more influential of his relatives were persuaded to encourage him to enter a career in science.

In 1882, he was awarded the degree of Doctor of Physics at Pisa, and in the following year, at age twenty-three, he was made a Full Professor of Mechanics, also at Pisa. In 1892, he moved to the University of Turin, and in 1900, he moved again, to take up the prestigious chair of Mathematical Physics at the University of Rome.

Volterra's scientific career was in many ways remarkable. His achievements in the field of integral equations were of the kind that made a lasting difference to the field; the Volterra equation, as one particular form of integral equation has come to be called (equation of the second kind with a variable limit) was solved by him in general form. Its importance in theoretical physics is such that it is an essential part of the equipment provided in the training of any young theoretician today.

He worked also in the related field of partial differential equations, and made significant contributions to the theory of wave propagation. His interest in the theory of elasticity led him to the study of multiple-valued functions and to the study of more general integro-differential equations. Ultimately, he was led, through this branch of analysis to deal with homeomorphisms and other aspects of algebraic topology.

His scientific curiosity led him in other directions as well, and he made important contributions in the domain of mathematical biology. He was able, for example, to derive results explaining the periodic fluctuations in predator-prey population statistics, an effect which had been observed but for which no explanation previously existed.

Volterra achieved early recognition within Italy. In 1905 he was created a Senator of the Kingdom of Italy; he was just forty-five years old at this time, and the honor was a great one. In 1914, he joined with other important figures, Bissolati, D'Annunzio and Barzilai among them, to urge publicly and insistently that Italy enter the war on the side of the Allies. When Italy entered the war in 1915, he enlisted in the army and joined the Air Force.

In 1917 he formed and headed the Office for War Inventions, and travelled in France and England on technical missions. He is recorded as being instrumental in persuading the Italian Parliament to continue to pursue the war after the terrible defeat at Caporetto.

Between wars, Volterra lived the life of a distinguished Roman citizen-scientist. His work was recognized by the award of honorary degrees from the Sorbonne, Oxford and Leningrad, among others; he was a member of many national academies throughout the world. He kept an apartment near the Piazza Colonna in Rome and a small country villa on the Appian Way, and was noted for his hospitality to visiting scholars.

But in 1931, the political world again intruded on his life. He refused to sign the oath of allegiance required by the Fascist government and was forced to resign from the University of Rome. Earlier, in 1922, he had signed the so-called ''Intellectuals' Declaration'' against Fascism; at that time, he was President of the highly esteemed Accademia dei Lincei, whose membership roster is centuries old, and includes Galileo himself. As a signatory to the Declaration, his name carried great weight; it can be no surprise that he would be singled out a decade later. In 1932, he was compelled to resign from all Italian scientific academies; but in 1936, he was nominated by Pius XI to the Pontifical Academy of Sciences, a membership he held until his death in 1940.

The Volterra collection which now comes to Brandeis University demonstrates the extraordinary breadth of Volterra's intellect. It is perhaps the richest and most complete selection anywhere of books and incunabula relating to the history of science and mathematics.

It is perhaps singularly appropriate that the Volterra Library should continue to remain intact at this University, where the collection will do honor to this most honorable of scholars.

VITO VOLTERRA: ACHIEVEMENTS OF THE SCIENTIST AND THE CITIZEN

Introduction

When the Second International Congress of Mathematicians met in Paris in 1900, the then forty-year-old Vito Volterra was a widely respected mathematician with an outstanding international reputation. One of his contributions to the Congress was a lecture with the title, ''Betti, Brioschi, Casorati: Three Italian analysts and three approaches to the questions of analysis.'' In his presentation, Volterra claimed that it would be impossible to understand and appreciate the impressive developments of Italian mathematics in the second half of the nineteenth century without studying the works of these three great mathematicians, whose ''labours [were] pursued with patience and energy over a great many years.'' All three had died within a few years of each other in the decade before the turn of the century. It was thus fitting to recall their achievements, particularly since Betti, Brioschi and Casorati in the fall of 1858 had visited together the leading mathematicians and scientific institutions of France and Germany and as Volterra insisted, ''the scientific existence of Italy as a nation'' dated from that journey. In his lecture Volterra reviewed their lives.

Brioschi (1824–1897), although trained as an engineer, gravitated towards pure mathematics, and at a very young age mastered the classical mathematical literature. In 1852, when Brioschi was but twenty-five years old, he was called to the chair of Mechanics at the University of Pavia. With the establishment of the monarchy Brioschi channeled some of his energies into political and public activities. In 1862 he organized and headed the Technical Institute at Milan. He remained its director until his death in 1897. He continued his mathematical researches while administering and teaching, also finding time to edit the ''Annali di Matematica,'' to be president of the Academia dei Lincei and to discharge his duties as senator by serving on numerous parliamentary commissions.

Volterra remarked that ''Betti's life was as calm as Brioschi's was agitated.'' Betti (1823–1892) had lost his father while quite young and had been raised by his mother. It was at the relatively old age of thirty-four that he first obtained a university chair at Pisa. Although appointed senator, Betti never took part in political activities. Scientific researches ''undertaken for their own sake, . . . with a philosophical goal'' was Betti's passion. When he had satisfied his need to understand ''the most hidden truths'' and had expressed these terms in the simplest principles ''all was done for Betti.'' He did not particularly care to make known his results. Many of his manuscripts were never completed, because while writing up his results, a new idea had occurred to him and he found it impossible not to pursue the inspiration of the moment.

According to Volterra, Casorati ''lived and worked almost exclusively for his students and for his school.'' His works are primarily pedagogical and critical, but Volterra commented, ''What originality in the criticism! What talent in his exposition of theory! . . . How many new unexpected results stemming from his correction of an error!''

All three were outstanding analysts who, as Volterra noted, had assimilated the spirit of Abel, Jacobi, Cauchy, Riemann and Weirstrass. Their mathematical accomplishments would have been reason enough for Volterra's address to the Congress. But one suspects other motives as well. Volterra had followed in their paths. He too had imbibed all the classical literature of mathematical analysis from Euler to Weirstrass and had chosen to be an analyst. Additionally, he had modeled his life after theirs, integrating with remarkable success their diverse styles. Volterra was to become, not only an outstanding mathematician, but also an outstanding teacher, administrator and public servant.

Volterra's Life

Vito Volterra was born on May 3, 1860 in Ancona, Italy, the only child of Abramo Volterra and Angelica Almagià. The Volterras' ancestry can be traced back to the Renaissance. This distinguished Jewish family first settled in Volterra, a small city in Tuscany, in 1408, when Bonaventura of Bologna was invited to open a loan bank there and adopted the name of the city as his own. It is reputed that this same Bonaventura was the copyist of a Hebrew work on logic. His son opened a bank in Florence in 1459. His grandson, Meshullam ben Menahem da Volterra was a friend of Lorenzo di Medici and is remembered for his recollections of his trip to the Holy Land. In 1481, he had sailed to Palestine and had stayed there for several months, travelling throughout the land recording all his observations with great perceptiveness and sensitivity [Adler 1930]. Another descendant, Hayyim ben Moses of Venice was well known for his rabbinic responsas. In 1714, the Inquisition became suspicious of some of his activities and he took refuge temporarily in London. Upon his return to Italy he settled in Ancona [Roth 1946, 1949].

When Vito was born, Ancona was under the rule of the Papal States. Shortly thereafter it was attacked by the Piedmontese army and Vito narrowly escaped death when a shell fell upon his house. Upon its capture, Ancona became part of the monarchy and Jews became accepted as equal members of the Italian society. When Vito was but two years old, his father died leaving the family in desperate straights. His uncle, Alfonso Almagià, an employee of the Banca Nazionale, took his sister into his home and raised Vito, first in Turin and then in Florence. It was in Florence that Vito spent the greater part of his youth and he came to think of himself as a Florentine.

In letters to his mother written as a teenager, Vito gives the impression of being somewhat withdrawn and very sensitive to outside opinions. By then he had already given indications of possessing remarkable intellectual faculties. At age eleven, he had studied by himself Bertrand's *Arithmetic* and Legendre's *Geometry,* and thereafter his passion for mathematics and physics never relented. At age nine, after reading some popular scientific books, the young Vito began to do experiments. In particular, he investigated the properties of torsion penduli and established the parameters determining their period of oscillation. At thirteen, after reading Jules Verne's *Around the Moon,* he tried to solve the problem of determining the trajectory of a projectile in the combined gravitational field of the earth and the moon. He devised a particularly ingenious way to solve the problem. He partitioned the time into very short intervals and assumed that during each of these intervals the gravitational force exerted on the projectile by the earth and the moon could be regarded as constant, so that the trajectory was obtained as a succession of small parabolic arcs.

At fourteen he studied Bertrand's *Calcul differentiel,* and discovered for himself the operation which was the inverse of differentiation, namely integration. After reading Faraday's *History of a Candle* he began chemical experimentation in the little laboratory he built in his house.

Although Vito never doubted that he ought to pursue a scientific career, his family insisted that he take up a commercial career. The differences were sufficiently sharp for the family to call upon a distant cousin, Eduardo Almagià, who held a doctorate in mathematics and engineering, to help arbitrate the conflict. Although the family had hoped that Eduardo Almagià would persuade Vito to accept their views, his interview with the teenager made it clear that Vito had exceptional talents. Impressed by Vito's sincerity, commitment and determination, Eduardo convinced the family to allow him to enter the Technical Institute of Florence to follow his vocation. Eduardo Almagià, incidentally, became one of the most successful civil engineers and financiers in Italy in the latter part of the nineteenth century. He also became Vito's father-in-law.

The matter of which career to follow was completely settled when Volterra was offered an assistantship under Professor Roiti in the Physical Laboratory of the University of Florence. In the spring of 1878, having completed the Technical Institute and passed the examinations in Greek and Latin, he enrolled in the Faculty of Natural Sciences at the University of Florence. That same year, he was accepted to the University of Pisa as a student in the Faculty of Mathematics and Physics. There he attended the lectures of Betti, Dini and Padova. In 1880, he entered the Scuola Normale Superiore where he remained for three years. These years at Pisa were among the happiest of his life. His friends there included Luigi Bianchi and Carlo Somigliana, who were to become outstanding mathematicians, the poets Guido Mazzoni and Giovanni Picciola and the philologist Francesco Novati. All of them remained his lifelong friends.

It was in 1880 while at Pisa that Volterra first met Mittag-Leffler, the eminent Swedish mathematician who was to be very helpful in initially disseminating Volterra's mathematical researches. In 1882, Volterra received his doctorate in physics with a thesis in hydrodynamics and obtained the position of assistant. In 1883, a commission composed of Betti, Beltrami and Brioschi nominated the twenty-three-year old assistant for the position of Professor of Rational Mechanics at the University of Pisa. Volterra remained at Pisa for ten years, assuming the chair in mathematical physics when Betti died in 1892. In 1893, he accepted a professorship at the University of Turin. He was called to the University of Rome as the successor of Beltrami in 1900. He remained in Rome for thirty-one years lecturing on mathematical physics and celestial mechanics. From 1907 to 1919 he was the Dean of the Faculty of Sciences.

In July of 1900, Volterra married Virginia Almagià, one of the daughters of his distinguished relative who had been responsible for his being able to pursue a scientific career. Six children were born of the marriage. Virginia Volterra, who for over forty years was Vito's devoted companion, assumed all the responsibilities which might have distracted her husband from his scientific work, and supervised the education of their children and the administration of their financial affairs. Their two sons achieved distinguished careers in law and in science.

In 1904 the Italian government requested Volterra to undertake the reorganization of the Technical Institute of Turin. It was in connection with this undertaking that

Volterra visited several foreign technical institutes including the ETH in Zurich and the École Polytechnique in Paris. In 1905 he was nominated senator of the Kingdom of Italy, and thereafter, for twenty-five years, he actively participated in parliamentary activities. He became particularly involved in formulating legislation for the organization of universities and of cultural activities. He was also responsible for the legislation regulating the investigations and utilization of radioactive substances, that for the creation of the committee supervising researches at higher institutions of learning, and that for the funding of oceanographic studies in Italy.

When World War I broke out, together with d'Annunzio, Volterra actively supported the cause of the Allies in the Senate. He was influential in getting Italy to enter the war on the side of France and Great Britain in May 1915. Not content with these efforts, Volterra also helped with the military preparation of his country. He spent the winter of 1915 in the high Alps carrying out experiments on the ballistics of projectiles shot from high altitudes. When Italy entered the war, Volterra, although then fifty-five, enlisted as an officer in the corps of engineers. Assigned to the air force, he lived for two years the life of an Italian aviator with youthful courage and enthusiasm. He designed new airships for antisubmarine warfare — he himself manned the guns in their use in the Adriatic — and also worked on the improvement of the firepower of airplanes.

In 1917, Volterra established the Italian Office of War Inventions and became its director. He established close ties with his French counterparts — Paul Painlevé, Emile Borel and Charles Maurin — and with the scientists heading the British antisubmarine warfare efforts at Harwich. He made frequent trips to France and to Great Britain, visiting battlefields and exposing himself to grave risks to test new equipment. It was in his capacity as Director of the Italian Office of War Inventions that Volterra proposed the employment of helium as a substitute for hydrogen in airships — he was the first to do so — and became involved in the manufacturing of this gas.

In 1919, to heal the wounds and rifts the war had created in the scientific community, he helped organize the International Council of Researches becoming its active vice-president. Together with Mittag-Leffler he tried to bring together German and Allied mathematicians.

When in October 1922, Mussolini came to power, Volterra was one of the first — and one of the few — to appreciate the threat Fascism posed to Italy's democratic institutions. He was one of the drafters of the "Intellectuals' Declaration" against Fascism, using his position as president of the Academia dei Lincei to enlist further support for the Declaration. When the government proposed certain changes in the educational system which deprived the Italian middle schools of their freedom, Volterra immediately challenged and opposed these moves. When the proposed "laws of national security" were debated by the Italian senate, Volterra, Benedetto Croce and Francesco Ruffini — at great personal risk — attended all the senate meetings and consistently voted against Mussolini. This after *all* the opponents of the government in the House of Deputies had withdrawn from the debates altogether.

By 1930 Mussolini had abolished the parliamentary government created by Cavour, and Volterra never again entered the Senate House. In 1931, having refused to take the oath of allegiance imposed by the Fascist government, he was dismissed from the University of Rome, where he had taught for over thirty years. In 1932 for similar reasons, he was deprived of all his memberships in Italian scientific academies. From this time forth, Volterra lived chiefly abroad, occasionally returning to his country home in Ariccia in the Alban Hills, south of Rome. Vito Volterra's comportment during these difficult years was exemplary: he embodied the ideal of the professoriat. His fearless and dedicated commitment to upholding freedom of expression and freedom of research, to guarantee the rights of everyone irrespective of his religious affiliation, and his efforts to alleviate human suffering deserve widespread dissemination. Only Einstein comes to mind in matching this record of integrity.

Much of his time after 1932 was spent in Paris, where he lectured every year at the Institut Henri Poincaré. He also gave lectures in Spain, Rumania, Czechoslovakia, Belgium and Switzerland. On all these journeys he was accompanied by his wife who never left his side. She then learned to type in order to prepare his papers for publication. Volterra used to say that the signature "V. Volterra" in his later works stood for Virginia Volterra. In 1938 he was afflicted by phlebitis and although his intellectual powers never abated, he progressively lost the use of his limbs. He died on the morning of October 11, 1940 at his house in Rome. He is buried in the cemetery of Ariccia near the country house he loved and in which he passed the serenest hours of his noble and active life.

In the words of Whittaker, who wrote his obituary for the Royal Society of London, "He had received countless honours." He was elected a Foreign Member of the Royal Society in 1910 and had received a similar distinction from almost every national academy and mathematical society in the world. He was a doctor *honoris causa* from Christiania (1902), Cambridge (1904), Clark University (1909), the Sorbonne (1919), Strasbourg (1919), Oxford (1926), Edinburgh (1922), Stockholm (1932), and St. Andrews (1938).

Volterra was active in numerous scientific organizations. In 1906, while attending a Congress of Naturalists in Milan, he organized the Italian Association for the Advancement of Science. The Society was founded in 1907 with Volterra as president. He was an active participant in many international conferences of mathematicians, philosophers, physicists, and biologists during his lifetime. He was president of the International Office of Weights and Measures from 1921 to his death, president of the Academia dei Lincei from 1923 to 1926, and editor of several mathematical journals. Beginning in 1900, Volterra travelled extensively and at one time or another lectured at all the major universities of Europe and those of North and South America. To him, being a scientist meant being a member of a community of searchers of truths, a community which transcended national boundaries and cultural differences. And for him to be a member of the community meant to *communicate* and this he did with a passion: he knew that the life of the community depended on it.

One other facet of Vito Volterra's life deserves comment: he was a dedicated and consummate bibliophile. During his extended travels he never missed an opportunity to rummage through antiquarians' shops. He loved books not only for their content, but also for their esthetic value or the rarity of their edition. During the course of his life he assembled and acquired one of the most extensive private collections of mathematical manuscripts, incunabula, and early imprints of the 16th and 17th centuries. His was probably the most impressive private collection of mathematical subjects ever assembled. It is a fitting testimonial to Volterra's erudition, taste and sense of value. It is this remarkable collection which Dr. Bern Dibner donated to Brandeis University and which has thus made its library one of the most attractive places for historians of science as well a mathematicians to turn to in order to study the past accomplishments of their fields.

Volterra's Scientific Work

In an invited lecture on the subject of "The Instruction of Mathematical Physics" given to the International Congress of Mathematicians of 1920, Volterra addressed the question of what kind of curriculum ought to be developed in order to meet the challenges of the future. In his address, Volterra sketched the history of the development of mathematical physics, having posed the question "To which moment in history can one ascribe the birth of mathematical physics, and what were the needs that were responsible for its creation?" The answer which Volterra gave was that the introduction of gun powder and the attendant problems of ballistics were responsible for the development of dynamics and of the infinitessimal calculus. Analytic mechanics became the foundation of cosmogonic theories "when Newton conceived the problem of the motion of the planets as a great problem of ballistics." Volterra further suggested that the problems connected with the art of construction were responsible for the development of the science of elasticity and of the strength of materials. The development of steam engines brought about Sadi Carnot's thermodynamics on the one hand, and on the other, Fourier's theory of the propagation of heat. The latter Volterra characterized as "the most beautiful edifice of mathematical physics" and the model of all other mathematical theories. Similarly Volterra claimed that it was the development of electric power based on Maxwell's insights and his partial differential equations, which was responsible for many of the mathematical advances in his own lifetime. Volterra further claimed that if the eighteenth century and the first half of the nineteenth were the centuries of *ordinary* differential equations, then the second half of the nineteenth was and the twentieth will be those in which *partial* differential equations, linear and nonlinear, as well as integro-differential equations would become the focus of mathematical physics.

Volterra's answers revealed his own approach to mathematical physics and were suggestive of the sources of his mathematical creativity. As indicated by the chronology of his published works, except for his early mathematical investigations in function theory carried out as a young student at Pisa under Dini's aegis, and his work while a young professor at Pisa carried out under Betti's influence, most of Volterra's later researches in "pure mathematics" were the result of his interest in applied problems. Thus his seminal work on the types of integral equations bearing his name stemmed from his investigations of the distribution of electric charge on segments of spheres. His researches in the theory of elasticity, which introduced the concept of a dislocation and transformed the field, were the point of departure for his theory of integro-differential equations. He also applied such equations to the description of substances whose electric and magnetic polarization exhibited hysterisis, that is, whose polarization depends *on the history* of the electromagnetic state of the matter at all previous times.

Even a cursory scan of Volterra's scientific work leaves one deeply impressed by the breadth of his erudition and of his interests, the elegance and simplicity of his mathematical insights, the fearlessness displayed in his computations. The other striking impression one obtains is his mastery of the current physical and mathematical literature. Within a few months of Fredholm's work on integral equations in 1900, Volterra had generalized his own theory of functional equations to include both his and Fredholm's equations. In 1912 he was already lecturing on Einstein's theory of relativity, having fully absorbed Minkowski's geometrical insights. In 1920, Volterra lectured at Berkeley on the flow of electricity in magnetic fields, shortly after hearing of Hall's work.

Whittaker in his obituary notice for the Royal Society and Carlo Somigliana in his preface to Volterra's *Collected Works* have succinctly reviewed his scientific work and I will not do so here. Instead let me briefly remark on some seminal contributions Volterra made to two different fields — contributions whose importance has increased enormously in recent years.

In 1940 Feynman discovered an alternative formulation of quantum mechanics in which the amplitude for a particle to go from the point x_a at time t_a to the point x_b at time t_b is computed as a sum of contributions from all possible trajectories that go between the end points $x_a t_a$ and $x_b t_b$. This is in contrast to the situation in classical mechanics in which there is but *one* particular path, the classical trajectory which the particle is assumed to follow in going from $x_a t_a$ to $x_b t_b$. The mathematics Feynman used to formulate his version of quantum mechanics is Volterra's theory of functionals (see for example, [Kline, 195, Chapter 46]). Feynman's approach using Volterra's functional method has proved of importance not only in giving valuable intuitive insights but also in charting new grounds in the quantum theory of fields [Feynman and Hibbs, 1965].

Volterra was one of the founding fathers of mathematical biology. Volterra's contributions to the applications of mathematics to biological phenomena began in 1901. Stimulated by conversations with his friend, the biologist D'Ancona, Volterra returned to the subject in 1925 and worked actively on population dynamics during the 1930s while in France.

Malthus in 1798 had observed that the population of Europe seemed to double at regular time intervals. Such behavior is the characteristic of an exponential growth. The rate of population increases, dN/dt, under such circumstances, is proportional to the population itself

$$dN/dt = \epsilon N$$

and the population at a time t, $N(t)$, is given by

$$N(t) = N(O) \exp \epsilon t$$

However, by the 1830s, several people had noted that the strength of the exponential process, ϵ, seemed to decrease. Quelelet, the great Belgian statistician, suggested that saturation might be expected. His student, Verhulst, to obtain saturation, added a density dependent correction to the Malthus equation:

$$dN/dt = \epsilon N [1 - N/K]$$

As a result of this added factor, the effective growth rate now had the density dependent from $\epsilon(1 - N/K)$ which is positive if $N < K$, negative if $N > K$ and thus led to a stable equilibrium value at $N^* = K$.

This equation was further generalized by Volterra to describe two interacting species, one of which (call it species 1) would grow exponentially in the absence of the second species (species 2) were it not preyed upon by it. Volterra also assumed that species 2 would die out with a rate constant ϵ_2 in the absence of species 1. He then proceeded to investigate the system of resulting equations

$$dN_1/dt = \epsilon_1 N_1 - \gamma_1 N_1 N_2$$

$$dN_2/dt = -\epsilon_2 N_2 + \gamma_2 N_1 N_2$$

and showed that N_1 and N_2 are periodic functions of the time. D'Ancona had found precisely such a variation in the population of certain prey-predator species of fish upon making a statistical analysis of fish catches in the Adriatic during the period from 1905 to 1923.

Volterra also generalized these considerations to a system of $2n$ species. His mathematical investigations were the point of departure of the science of theoretical ecology which has yielded important biological insights in recent years [May 1975].

Epilogue

In 1925, Alfred Lotka, who independently of Volterra, had applied mathematical methods to biological problems and had also arrived at the prey-predator population equations stated that:

> The whole development of science is a record of tearing down barriers between separate fields of knowledge and investigation.

Volterra's lifetime work can be regarded as having advanced knowledge by tearing down barriers. Any ensemble of units — whether it is made up of atoms, molecules, organisms or species — exhibits phenomena that often cannot be deduced from the characteristics of an isolated unit of the ensemble. Volterra used mathematics to develop concepts to help understand such phenomena. Just as the physicist's cyclotron, the biologist's microscope, mathematics for Volterra was the essential instrument for making the unseen visible.

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Volume XXIII (1941) of *Archeion* contains an article entitled "Materiaux pour une Biographie du Mathematicien Vito Volterra," as well as bibliography of his works.

The bulk of Volterra's scientific writings were reprinted Vito Volterra, *Opere Matematiche,* 5 volumes, (Rome: Academia Nazionale dei Lincei 1960), Volume 1 contains a brief biographical essay and Volume 5 a complete bibliography of his scientific output.

GUIDE TO SPECIAL COLLECTIONS IN THE BRANDEIS UNIVERSITY LIBRARY

Founded in 1961, the Society of Bibliophiles at Brandeis University has dedicated itself to fostering and developing the Special Collections Department of the University Library essentially through gifts of the kind of materials which the Library is unable to acquire through its budgeted operating funds. At its annual meetings there is displayed a small selection of the items donated by the members during the year. No exhibition on this scale can possibly do justice to the wealth, variety, and significance of the works presented. In 1969 a more extensive exhibition of selected books and manuscripts was mounted and a record preserved in a catalogue entitled *Libri varii.* In subsequent years the Society has reverted to the more modest display.

Other than walking through the storage vault there was no way of attaining a sense of direction and accomplishment reflecting the benefactions of the members. At the Tenth Anniversary Meeting in 1971 the Society suggested the preparation of an up to date record of the collections in the Special Collections Department. In the light of the many internal problems the assignment was not easily accomplished but a preliminary inventory was prepared and published in *Octavo* No. 3. (Fall 1972), pp. 16–20. For the Twentieth Anniversary Meeting a revised and expanded listing has been prepared for publication in *Octavo* No. 5 (Fall 1981).

There have been benefactions from non-members but the vast bulk of the material administered by the Special Collections Department has come from members of the Society. In light of the cataloguing back-log and the state of the records it is not possible to present a precise statistical accounting. Unfortunately, no records were kept during the first nine years of the Society's existence, a period when benefactions were numerous and extensive and are conservatively estimated to have exceeded 10,000 items. But from 1970 through 1981 members of the Society of Bibliophiles have presented slightly more than 40,000 items to the Special Collections Department. This figure does not include the many gifts from members which are processed as part of the general collection of the Library.

The steady increase in the collections administered by the Special Collections Department is of course a matter of great satisfaction to the Society whose sole interest is in this aspect of the Library's development. The over-all growth of the Library remains the responsibility of the National Women's Committee whose contribution constitutes a matchless endowment. It should be noted that the present listing excludes the "Special Collection Shelves" which the National Women's Committee has sponsored over the years.

The present list then reflects the substantial achievements of the Society of Bibliophiles in the first twenty years of its existence. But as every collector knows this is an area of infinite possibilities. And with the increasing awareness among collectors and library administrators of the strategic importance of special collections for future generations of researchers the competition heightens for significant acquisitions. While the Society may legitimately take pride in what it has accomplished in twenty years, it must not let satisfaction slacken the pace as it turns to the uncharted future with renewed dedication and zeal.

A. *Reference Works*
- Auction Catalogue File
- Bibliography (David S. Berkowitz)
- Book Arts
- History of Printing & Publishing (Thomas R. Franklin)
- McMurtrie Imprints (Society of Bibliophiles)

B. *Fine Presses & Private Printing before 1801*
- Xylographs & Incunables (Bern Dibner, Lura Swig, Walter Goldwater, Philip D. Sang)
- Aldine (Philip Neufeld, Bruno Weil, Walter Goldwater, Mrs. Ludwig Lewisohn)
- Elzevir
- Estienne
- Foulis Press
- Plantin

C. *Fine Presses & Private Printing after 1801*
- Ashendene Press
- John Baskerville Press
- Bird & Bull Press
- Black Cat Press
- Black Sparrow Press
- Black Sun Press
- Book Club of California
- Cuala Press
- Elm Tree Press
- Gehenna Press
- Golden Cockerel
- Grabhorn Press
- Lee Priory Press
- Mosher Press
- Nonesuch Press
- Oriole Press
- William Pickering Imprints
- Prairie Press
- Rather Press
- Signet Press
- Sumac Press
- Windsor Press

D. *Bibliophilic Specialties*
- Association Copies
- Presentation Copies
- Fore Edge Paintings
- Miniature Books
- Special Bindings

E. *History, Politics, Economics, Sociology*
- *General*
  - Jewish Resistance Movements in World War II (Robert Rolde)
  - Continental Imprints, 1475–1800
  - Josephus Flavius (Walter Goldwater)

- *America*
  - American Conservatism Pamphlets
  - American Radicalism Pamphlets

American Imprints — 1639–1830
Louis D. Brandeis Collection
Dime Novel Collection (Edward Levy, Edward LeBlanc)
Leo Frank Collection
History of Brandeis University
Perry Miller Early American Religious Literature (Mrs. Perry Miller)
Franklin Roosevelt (Benjamin Arac)
Sacco-Vanzetti (Francis Russell)

Bolivia
Bolivian Political Literature (19th & 20th Cent.)

England
English Imprints, 1475–1800

France
Alfred Dreyfus (Helen Slosberg)
Mazarinades (Walter Goldwater)
French Revolution Pamphlets (Society of Bibliophiles)

Germany
Eduard Lasker Papers

Spain
Spanish Civil War Books, Pamphlets, and Ephemera

F. *Exploration*
Magellan and the Age of Discovery (Charles McKew Parr)

G. *Literature*
American
Horatio Alger (Edward Levy)
American Juvenilia (Edward Levy, Edward LeBlanc)
American Literary First Editions (Frank T. Crohn)
Ernest Hemingway (Alfred Rice)
Henry James Collection (Albert Boni)
Ludwig Lewisohn (Mrs. Ludwig Lewisohn)
Lizette Woodward Reese (Philip Neufeld)
Walt Whitman (Mitchell Slobodek)

English
English Romantic Period Literature (Henry Hofheimer)
Joseph Conrad (Philip Pinsof)
John Galsworthy
The Spectator

Germany
    Karl Kraus (Oskar Samek)

H. *Religion*
    Liturgical Collection (Maurice Spertus)
    Near Eastern Religions (George A. Barton)

I. *Graphic Arts & Books*
    American
        Lincolnia Prints and Photographs (Justin Turner, Benjamin Arac)
        Rockwell Kent (Bern Dibner)
        World War I Posters (Benjamin Arac)

    English
        William Blake Trianon Press Facsimile Editions

    European
        Early Illustrated Books (Arthur Vershbow)

    French
        Daumier Lithographs (Benjamin A. & Julia M. Trustman)
        French 20th Century Graphics (Samuel Glaser)

    Spanish
        Spanish Civil War Posters (Society of Bibliophiles)

J. *Science*
        Leonardo Da Vinci (Bern Dibner)
        Vito Volterra Collection on the History of Science (Bern Dibner)

K. *Orientalia*
        Japanese Imprints (Philip Pinsof)

L. *Music*
        Reginald De Koven Scores
        Early American Sheet Music (Daniel Siegel)

M. *Photographica*
        Carl Van Vechten Collection

N. *Manuscripts* (excluding Spanish Civil War, Archives & Personalia)
    General
        Autograph Letters (arranged alphabetically)
    American
        George A. Barton Papers

- George N. Caylor Journals
- John Cheever Literary Mss.
- Chief Justices of the United States (Philip D. Sang)
- Joseph Heller Literary Mss.
- Fanny Hurst Literary Mss.
- Louis Kronenberger Mss.
- Ludwig Lewisohn Correspondence
- Leo Rosten Literary Mss.
- Sacco-Vanzetti Collection
- Signers of the Constitution (Philip D. Sang)
- Signers of the Declaration of Independence (Philip D. Sang)
- Daniel Webster Correspondence (Philip D. Sang)
- Frank Zwillinger Literary Mss.

British
- John Galsworthy Correspondence (Joseph M. Jacobs)

French
- Marcel Proust Correspondence

Judaica & Hebraica
- Megillahs
- Miscellany

Russian
- Tolstoy Correspondence and Literary Mss. (Society of Bibliophiles)

O. *Archives*
- Abraham Lincoln Brigade
- Consistoire Israelite — French Jewry 1790–1905
- Letters of Louis D. Brandeis
- David E. Niles Papers

P. *Non-Book Materials*
- Numismatics
- Presidential Commemorative Medals
- Philatelic Material
  - Leo Sheinfeld Collection of Israeli Stamps
- Ceramics
  - Dr. & Mrs. Bernard H. Kessner Collection of Doughty Birds
- Paintings
- Snuff Bottles
  - Jack Katz Collection

THE SOCIETY OF BIBLIOPHILES AT BRANDEIS UNIVERSITY

IN THE LONG AND NOBLE TRADITION OF BIBLIOPHILIA SOME COLLECTORS HAVE ASSEMBLED NOTEWORTHY MATERIALS PRIMARILY TO GRATIFY THEIR OWN INTERESTS WHILE OTHERS HAVE EMPLOYED THEIR KNOWLEDGE AND EXPERTISE TO CONTRIBUTE TO THE FUTURE ADVANCEMENT OF LEARNING. IT IS THUS ON BEHALF OF GENERATIONS YET UNBORN THAT WE ASSEMBLE THIS DAY AT OUR TWENTIETH ANNIVERSARY MEETING TO HONOR

BERN DIBNER

SC.D. *HONORIS CAUSA*, BRANDEIS UNIVERSITY, 1977

INDUSTRIALIST, SCHOLAR, BIBLIOPHILE AND GENEROUS BENEFACTOR, FOUNDER OF PRE-EMINENT COLLECTIONS AT THE BURNDY LIBRARY, THE SMITHSONIAN INSTITUTION, AND THE DONOR EARLIER TO BRANDEIS UNIVERSITY OF THE LEONARDO DA VINCI AND ROCKWELL KENT COLLECTIONS; AND NOW THIS MORNING PUBLICLY PRESENTING TO THE BRANDEIS UNIVERSITY LIBRARY THE VITO VOLTERRA COLLECTION, ONE OF THE WORLD'S PREMIER ASSEMBLAGES IN THE HISTORY OF SCIENCE, AN AREA IN WHICH DR. DIBNER HAS HIMSELF LABORED WITH DISTINCTION BOTH AS A SCHOLAR AND AS A COLLECTOR.

IN FULL CONFIDENCE THAT POSTERITY WILL LONG REAP THE FRUITS OF THIS BENEFACTION WE HERE RECORD THEIR APPRECIATION AS WELL AS OURS FOR THIS GIFT WHICH WILL ENABLE SCHOLARS EVERYWHERE TO PRESERVE AND ENHANCE KNOWLEDGE IN THE SPIRIT OF SIR FRANCIS BACON'S PRINCIPLE THAT "NATURE TO BE COMMANDED MUST FIRST BE OBEYED."

GIVEN THIS THIRTY-FIRST DAY OF OCTOBER IN THE YEAR ONE THOUSAND NINE HUNDRED AND EIGHTY-ONE AT BRANDEIS UNIVERSITY IN THE CITY OF WALTHAM, COMMONWEALTH OF MASSACHUSETTS, IN WITNESS WHEREOF IS APPENDED THE SIGNATURES OF OUR OFFICERS AND THE SEAL OF BRANDEIS UNIVERSITY: